INSTRUCTION MANUAL

MODEL 1554-2
CRYSTAL-BOLOMETER
AMPLIFIER

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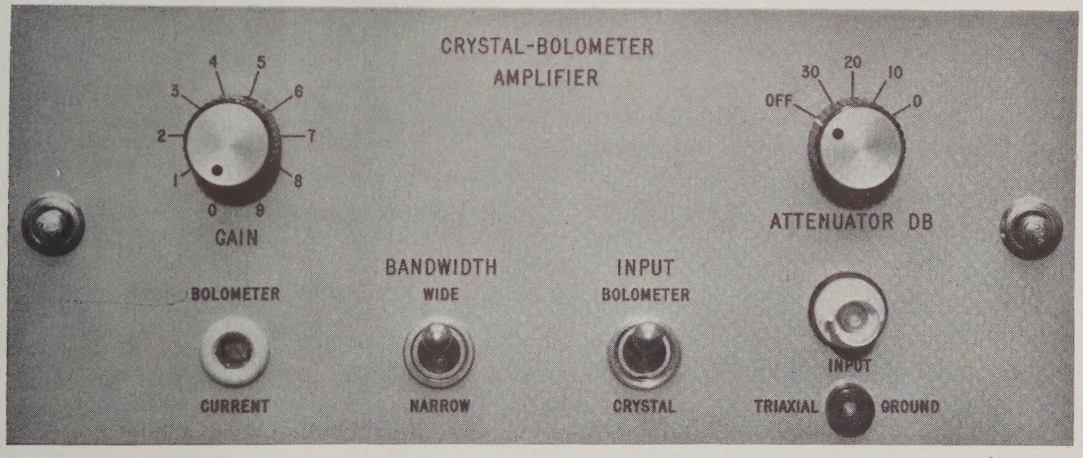

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CHAPTER 1
GENERAL INFORMATION

1.1 Introduction

The Model 1554-2 Crystal-Bolometer Amplifier is a miniature plug-in unit intended for use as a preamplifier with the Scientific-Atlanta Series 1520 Rectangular and 1530 Polar Pattern Recorders. This unit is a sensitive amplifier which can be operated from the output of a crystal detector or a bolometer detector. The amplifier permits selection of wide-band operation (±1.5% of the center frequency) or narrow-band operation (±3 cps). The center frequency of the amplifier is determined by plug-in filters. Filters are available at any frequency between 500 cps and 2500 cps. Unless a special frequency is requested, the unit is furnished with a center frequency of 1000 cps for operation from a 60-cps power line and 1025 cps for operation from a 50-cps power line.

A transistor circuit provides bolometer bias with constant current regulation and helps prevent bolometer burnout in case the bolometer connection is broken and reconnected with bolometer bias applied.

1.2 Specifications

	Wide Band	Narrow Band
Gain		
Crystal Input	90 db	94 db
Bolometer Input	98 db	102 db
Input Impedance		
Crystal Input	5000 ohms	5000 ohms
Bolometer Input	1000 ohms	1000 ohms
Center Frequency		
Standard 60-cps Line	1000 cps	1000 cps
Standard 50-cps Line	1025 cps	1025 cps
Bandwidth (3 db, 1000 cps)	±15 cps	±3 cps
Noise Level (200-ohm source impedance)	0.012 μv	0.006 μv
Bolometer Bias (Range)	0-15 ma	0-15 ma
Attenuation*		
Fixed	Three 20-db steps	
Variable	0-20 db minimum	
Attenuation Accuracy (Fixed)	±0.1 db	
Dynamic Range	80 db	

*All 20-db attenuation ranges are labeled as 10-db ranges to correspond to the signal variation on the RF side of a square-law detector.

Input Connectors (Front and Rear)	BNC
Plate Supply Requirements	+250v at 15 ma
Filament Supply Requirements	+13v dc at 0.5a
Front-Panel Size	3.47 in. x 8.47 in.

CHAPTER 2
OPERATION

2.1 General Operating Precautions

To obtain maximum sensitivity from the crystal-bolometer amplifier, care should be taken to eliminate excessive 60-cps pickup in the input cable. The interference may cause slow beating of the recorder pen at low values of signal input level. Although the crystal-bolometer amplifier has very high rejection to 60-cps input voltages, the extreme sensitivity of this amplifier will permit large values of 60-cps input voltages to be detectable in the presence of low levels of input signal.

The crystal-bolometer amplifier and antenna pattern recorders are designed to minimize all internal sources of noise and 60-cps hum pickup. The pattern recorder includes a well filtered dc filament supply which is used for all sensitive amplifier stages. All ground circuits are arranged to eliminate ground loops which could result in inter-circuit coupling. Adequate electrostatic and magnetic shielding is provided throughout the pattern recorder.

Hum at the amplifier input, exclusive of any which may be associated with the received signal, occurs when 60-cps currents of an appreciable value are permitted to flow in the shield of the coaxial cable connecting the crystal-bolometer amplifier input connectors to the detector. This effect is noticeable when the detector mount is connected to a ground system which is not at zero potential with respect to the pattern recorder ground. The pattern recorder is furnished with a ground connection at the power plug. This ground should be connected to a separate ground wire, not ac common.

Unwanted 60-cps pickup can occur if the coaxial cable connecting the detector mount to the crystal-bolometer amplifier is run in the vicinity of 60-cps magnetic fields. A power cable run beside the input coaxial cable will induce 60-cps currents in the shield. To reduce 60-cps pickup effects to a minimum, proper grounding or complete isolation of the detector mount from ground is necessary; in addition, adequate isolation of the interconnecting coaxial cable from magnetic fields is necessary.

The effects of unwanted currents flowing in the shield of the input cable can be minimized by use of a triaxial input cable. If the inner and outer shields are tied together at the detector end and connected to the shell of a BNC connector, a coaxial connection can be made to the detector. At the crystal-bolometer amplifier input, the inner shield and the center conductor should be connected to a BNC connector for connection to the input, and the outer shield should be connected to a test lead plug and inserted

in the TRIAXIAL GROUND jack provided on the front of the amplifier. A triaxial cable which is satisfactory for this purpose is Amphenol Type 21-204, or equivalent.

The lengths and types of coaxial cables used between the detector mount and the crystal-bolometer amplifier may vary considerably. The effects of cable length on pattern-recorder operation are those relating to hum pickup and signal deterioration. Cable lengths of several thousand feet may be used without undesirable effects, provided the cable is properly isolated from magnetic and electrostatic fields.

An excellent coaxial cable for use between the detector mount and the crystal-bolometer amplifier is type RG-62/U. This cable is recommended because of its small size, flexibility, high impedance, and low capacity; however, many other cables are suitable and may be used.

2.2 Operation From a Crystal Detector

Refer to paragraph 2.1.

For operation of the crystal-bolometer amplifier from the detected audio output of a crystal detector, place the INPUT switch in the CRYSTAL position.

Connect the output of the crystal mount by means of a length of coaxial cable to either the front-panel INPUT connector (A1J1) or the rear Signal Input connector (A1J2).

With an amplitude-modulated RF signal applied to the detector, adjust the modulation frequency to correspond to the center frequency of the crystal-bolometer amplifier. This will be indicated by maximum recorder pen deflection. The fixed and variable gain controls may be set to obtain the desired recorder sensitivity.

2.3 Operation From a Bolometer Detector

Refer to paragraph 2.1.

For operation of the crystal-bolometer amplifier from the detected audio output of a bolometer detector, place the INPUT switch in the BOLOMETER position, and place the METER FUNCTION switch (on the Series 1555 Pen Function Amplifier or the Model 1559 Amplifier Power Supply) in the BOLOMETER CURRENT position.

Turn the BOLOMETER CURRENT control fully counterclockwise.

Connect the output of the bolometer mount by means of a length of coaxial cable to either the front-panel INPUT connector (A1J1) or the rear Signal Input connector (A1J2).

While observing the meter, turn the BOLOMETER CURRENT control clockwise until the recommended bolometer current level is reached (between 0 and 15 ma).

Place the METER FUNCTION switch (on the Series 1555 Pen Function Amplifier) in either the OFF or one of the SIGNAL positions. If the crystal-bolometer amplifier is located in the Model 1559 Amplifier Power Supply, place the METER switch in the OFF position. (This removes the meter from the bolometer circuit and eliminates noise generated by meter vibration.)

With an amplitude-modulated RF signal applied to the bolometer, adjust the modulation frequency to correspond to the center frequency of the crystal-bolometer amplifier. This will be indicated by maximum recorder pen deflection. The fixed and variable gain controls may be set to obtain the desired recorder sensitivity.

> NOTE: A voltage-limiting circuit is included as part of the bolometer bias circuit. This circuit helps prevent bolometer burnout if the bolometer is disconnected and reconnected with bias applied.

2.4 Parallel Operation of Crystal-Bolometer Amplifiers

It is often convenient and desirable to operate two pattern recorders simultaneously from one detector mount for simultaneous plotting of two pen functions and/or a polar and rectangular pattern. To permit parallel operation of crystal-bolometer amplifiers, the crystal inputs are capacity-coupled to the input transformer.

The procedure for parallel operation is as follows:

(a) For operation from either a crystal detector or a bolometer detector, connect one crystal-bolometer amplifier as described in paragraph 2.2 or 2.3.

(b) Break the coaxial line between the detector mount and the input of the crystal-bolometer amplifier, and add a coaxial tee connector.

(c) Connect the third arm of the coaxial tee by means of a coaxial cable to one of the inputs located on the second crystal-bolometer amplifier.

(d) Place the INPUT switch of the second amplifier in the CRYSTAL position.

(e) Both crystal-bolometer amplifiers may now be independently adjusted to provide the desired recording sensitivities.

NOTE: Parallel operation will reduce the overall gain of each crystal-bolometer amplifier by less than 6 db.

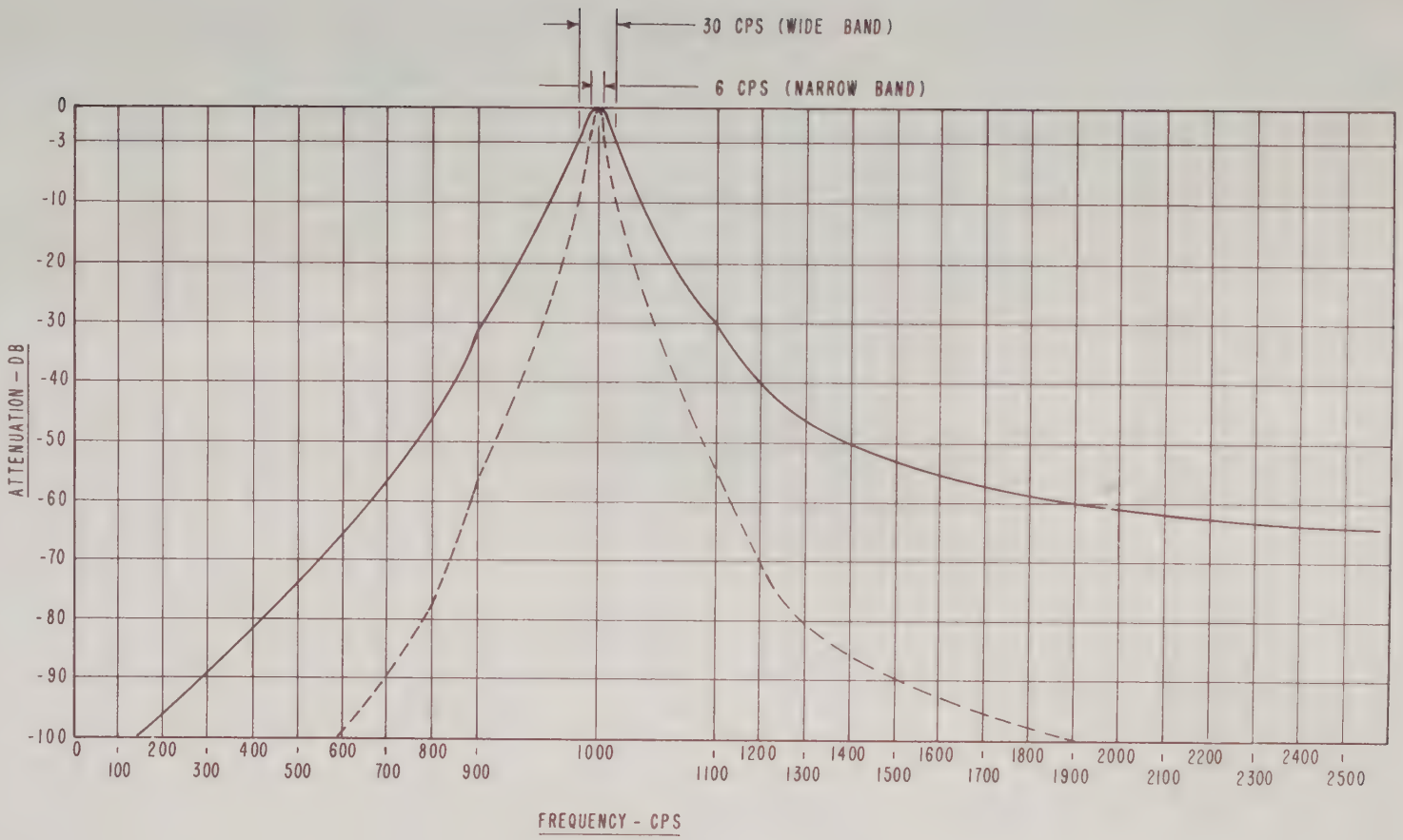
2.5 Amplifier Saturation

The crystal-bolometer amplifier will not saturate when the pattern recorder pen is on the recording scale during normal recorder operation. However, when only the signal-level meter located on the front panel of the pen function amplifier is used, it is possible to overdrive the crystal-bolometer amplifier and still be at less than full scale on the meter. Under this condition, the meter scale will be inaccurate. To avoid this condition, always operate the crystal-bolometer amplifier at an output level below saturation (at or below full scale on the recorder) and use the separate attenuators associated with the signal-level meter to obtain the desired meter deflection.

2.6 Amplifier Bandwidth Considerations

The overall frequency response of the crystal-bolometer amplifier tuned to a center frequency of 1000 cps is shown by Fig. 2.1. As is indicated for wide-band operation, the half-power bandwidth is 30 cps; and the rejection to 60 cps is greater than 100 db.

Occasionally, it is necessary to operate two nearby pattern ranges at frequencies within the same band. Difficulties can arise due to inter-range interference. This situation may be improved by providing different audio-modulation frequencies for each pattern range transmitter. By spacing the modulation frequencies sufficiently to obtain a maximum rejection of the interfering signal by each crystal-bolometer amplifier, the interference effect is minimized. For example, considering the shape of the narrow-band frequency response curve of Fig. 2.1, if two crystal-bolometer amplifiers are selected at center frequencies of 800 cps and 1000 cps, the 800-cps amplifier will provide approximately −70 db rejection to 1000 cps; and the 1000-cps amplifier will provide −70 db rejection to 800 cps and −93 db rejection to the 1600-cps second harmonic.



Solid line: wide-band operation. Dashed line: narrow-band operation.

Fig. 2.1. Frequency Response of Crystal-Bolometer Amplifier (Center Frequency = 1000 cps)

CHAPTER 3
DETAILED DESCRIPTION

3.1 Input Circuit

A schematic diagram of the crystal-bolometer amplifier is shown at the rear of this manual. The amplifier is furnished with separate crystal and bolometer front- and rear-panel BNC coaxial connectors. The crystal inputs are capacity-coupled to a high-impedance tap of the input transformer.

When operating from a crystal detector, A1S3 is placed in the CRYSTAL position, returning terminal 3 of input transformer A1T1 to the coaxial input ground. The crystal detector input at either A1J2 or A1J1 is capacity-coupled to terminal 1 of A1T1 to provide a 5000-ohm input impedance.

To permit adjustment of a bolometer detector bias level, A1S3 is placed in the BOLOMETER position. BOLOMETER CURRENT potentiometer A1R30 provides a range of bias current from 0 to 15 ma with most standard bolometers. The BOLOMETER CURRENT position of METER FUNCTION switch A2S3 (located on the Series 1555 Pen Function Amplifier) is used only for monitoring bolometer bias current; A2S3 should be placed in either the OFF or one of the SIGNAL positions for operation. In this position of A2S3, the meter (A2M1) is removed from the circuit to eliminate noise generated in the meter due to mechanical vibration.

Capacitor A1C1 provides a low-impedance signal return from terminal 3 of A1T1 to the signal input ground during operation in the BOLOMETER position of A1S3.

Transistor A1Q1 provides constant current regulation and limiting of the voltage to which A1C1 charges with the amplifier input disconnected. This prevents bolometer burnout if the bolometer is connected with bias applied.

Input transformer A1T1 provides an input impedance of 1000 ohms at the bolometer input.

3.2 Intermediate Stages

Step attenuator A1S1 provides three 20-db fixed-attenuation steps in addition to an OFF position. Each attenuation step is located at a separate point in the amplifier to prevent amplifier overload. A variable attenuation of 20 db is provided by GAIN potentiometer A1R7 which determines the amount of negative feedback coupled from the plate to the grid of A1V1. A1V1 and A1V2 are low-noise resistance-coupled

amplifiers. Wirewound plate-load resistors A1R4 and A1R10 are used to minimize noise generated within these components.

Tube A1V3 attenuator is a cathode follower which isolates the high-impedance output of the last attenuator section (A1A1) from the low-impedance input of the wide-band or narrow-band filters (A1A1 or A1A2). Filters A1A1 and A1A2 are plug-in bandpass filters and may be selected at any center frequency between 500 cps and 2500 cps. Unless otherwise specified, filters for a center frequency of 1000 cps are furnished.

3.3 Output Circuit

Tube A1V4 is a resistance-coupled amplifier which drives parallel power-amplifier stages A1V5 and A1V6. The signal at the plates of A1V5 and A1V6 is degeneratively coupled to the cathode of A1V4 by A1R19 and A1C13.

Transformer A1T2 has two outputs: Resistor A1R38 in series with the high-level output (pin 5) of A1T2 increases the source impedance of the amplifier to 1440 ohms to properly match the recorder logarithmic potentiometer. The low-level, low-impedance output (pin 7) of A1T2 is used when the recorder is operating with a linear or square-root pen function.

Connector A1J4 (High Signal Output), located at the rear of the unit, permits monitoring of the ac amplifier output. The impedance of the high-signal output circuit is 1440 ohms. The output level at A1J4 is normally 10v rms when the recorder is at full scale in the logarithmic function.

3.4 Power Input

The output-signal and input-power connections to the crystal-bolometer amplifier are made through connector A1J3. The filament voltage and plate-supply voltages are obtained from the pattern recorder. A filament supply of +13v at 0.5a and a plate supply of +250v at 15 ma are required.

Every precaution has been taken in the crystal-bolometer amplifier design and construction to reduce hum pickup to a minimum--A1T1, A1T2, A1A1, and A1A2 have high-permeability shielding, and the entire crystal-bolometer amplifier is shielded when plugged into the pattern recorder. DC filaments are used throughout to minimize 60-cps pickup.

CHAPTER 4
MAINTENANCE

4.1 General

In the event of faulty operation of any part of the crystal-bolometer amplifier, a visual inspection of tubes, cable connections, and other components should be completed first. Afterward, standard maintenance procedures should be followed to isolate the trouble to a particular stage and then to the defective component.

The voltage and gain tables that follow permit testing the static and dynamic circuit operation.

4.2 Static Measurements

Table 4.1 shows typical values of dc voltage present at the tube and transistor pins during normal operation. These voltages are measured with respect to ground using a 20,000 ohms-per-volt voltmeter, and are subject to a tolerance of ±10%. During measurement the ATTENUATOR should be set to the OFF position.

Table 4.1. Static DC Voltages During Normal Operation.

TUBE OR TRANSISTOR	PIN NUMBERS							
	2	4	8	10	12	B	E	C
A1Q1*	--	--	--	--	--	+4.2	+4.4	+0.5
A1V1	+83	0	+2.5	+13	0	--	--	--
A1V2	+95	0	+1.4	+13	0	--	--	--
A1V3	+150	0	+3.0	+13	0	--	--	--
A1V4	+115	0	+1.6	+13	0	--	--	--
A1V5	+135	0	+1.6	+13	0	--	--	--
A1V6	+135	0	+1.6	+13	0	--	--	--

*BOLOMETER CURRENT control fully clockwise;
INPUT switch in CRYSTAL position.

4.3 Dynamic Measurements

Table 4.2 shows typical values of voltage-gain-per-stage for the crystal-bolometer amplifier during normal operation. These measurements were made with the GAIN control fully clockwise and the ATTENUATOR set to 0.

The values of gain were taken with 1000-cps center-frequency filters installed and with a 1000-cps signal applied to the INPUT connector. The recorder pen was switched ON during the gain measurements to provide an indication of amplifier loading.

Table 4.2. Voltage Gain Measurements During Normal Operation

GAIN MEASURED		VOLTAGE GAIN	
From	To	Narrow Band	Wide Band
A1J1 or A1J2	Pin 4, A1V1	27 db*	27 db*
A1J1 or A1J2	Pin 4, A1V1	19 db**	19 db**
Pin 4, A1V1	Pin 4, A1V2	27 db	27 db
Pin 4, A1V2	Pin 4, A1V3	27 db	27 db
Pin 4, A1V3	Pin 4, A1V4	1.5 db	-5 db
Pin 4, A1V4	Pin 4, A1V5	5 db	5 db
Pin 4, A1V5	A1J4	18 db	18 db

*INPUT switch in BOLOMETER position.
**INPUT switch in CRYSTAL position.

4.4 Component Boards

The two component boards under the chassis are marked with the designations of the major components. Each board can be swung up into a vertical position for servicing if necessary.

To shock mount the boards, the nuts on the board-mounting bolts are not tightened and rubber grommets are used next to the board and the chassis. Replace all washers, spacers, and grommets when reinstalling the boards. Leave three or four threads showing on the bolts when tightening the nuts.

CHAPTER 5
REPLACEMENT PARTS LIST

MANUFACTURERS' CODE LETTERS

Code	Manufacturer
A	Aerovox
ABE	Amphenol-Borg
BDY	Bundy Electronics
BLI	Bourns
CD	Cornell-Dubilier
CH	Cutler-Hammer
CRL	Centralab
D	Dage
DP	Dale Products
IRC	International Resistance
J	E. F. Johnson
O	Ohmite (LD = Little Devil)
PPI	Polyphase Instrument Company
RCA	Radio Corporation of America
TO	Tru-Ohm
TOT	Tarotel
TT	Triad
UTC	United Transformer
XX	Any brand diode or transistor which meets JEDEC standards

The component designations for parts in the Model 1554-2 Crystal-Bolometer Amplifier are prefixed with A1. This prefix represents the first major sub-assembly in the Series 1520 or 1530 Recorder. See the recorder instruction manual for further information.

PARTS LIST

MODEL 1554-2 CRYSTAL-BOLOMETER AMPLIFIER

The component designations are abbreviated. Prefix each component with the number shown below.

A1

Component Designation	Description	Mfr. *	Mfr. Part No.
A1	Filter, narrow-band, plug-in	PPI	BPF101613
A2	Filter, wide-band, plug-in	TOT	11473
C1	Capacitor, fixed, electrolytic, 100 µf, 25v	A	PWE25100
C2	Capacitor, fixed, Mylar, 0.47 µf, 100v	CD	WMF1P47
C3 C7	Capacitor, fixed, electrolytic, 5 µf, 25v	A	PWE25005
C4	Capacitor, fixed, Mylar, 0.022 µf, 400v	CD	WMF4S22
C5 C6	Capacitor, fixed, ceramic disc, 470 pf, 1000v	CRL	DD-471
C7	See C3		
C8	Capacitor, fixed, Mylar, 0.047 µf, 400v	CD	WMF4S47
C9 C13	Capacitor, fixed, Mylar, 0.1 µf, 400v	CD	WMF4P1
C10 C15	Capacitor, fixed, electrolytic, 10 µf, 450v	A	PRS1720
C11	Capacitor, fixed, silver mica, factory-selected, 500v	CD	CD15-5T
C12	Capacitor, fixed, Mylar, 0.033 µf, 400v	CD	WMF4S33
C13	See C9		
C14	Capacitor, fixed, electrolytic, 25 µf, 25v	A	PWE25025
C15	See C10		
C16	Capacitor, fixed, disc, 250 pf	CRL	DD-251
CR1	Diode, silicon	XX	1N277
J1 J2 J4	Connector, coaxial, BNC	D	UG-657/U
J3	Connector, receptacle, female, 14 contacts	ABE	57-40140
J4	See J1		
J5	Test jack, black	J	105-603
Q1	Transistor, germanium, PNP	XX	2N404
R1	Resistor, fixed, wirewound, 5 ohms ±5%, 3w	TO	VAL-3
R2	Resistor, fixed, deposited carbon, 909,000 ohms ±1%, 1/4w	DP	DCF-1/4
R3	Resistor, fixed, deposited carbon, 100,000 ohms ±1%, 1/4w	DP	DCF-1/4
R4 R10	Resistor, fixed, wirewound, 51,000 ohms ±5%, 5w	IRC	AS-5
R5	Resistor, fixed, composition, 1200 ohms ±10%, 1/2w	O	LD
R6	Resistor, fixed, composition, 22,000 ohms ±10%, 1/4w	O	LD
R7	Resistor, variable, wirewound, 50,000 ohms ±3%, 2w	BLI	3500S-1-503
R8	Resistor, fixed, deposited carbon, 182,000 ohms ±1%, 1/4w	DP	DCF-1/4
R9	Resistor, fixed, deposited carbon, 20,000 ohms ±1%, 1/4w	DP	DCF-1/4
R10	See R4		

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL 1554-2 CRYSTAL-BOLOMETER AMPLIFIER-continued

The component designations are abbreviated. Prefix each component with the number shown below.

A1

Component Designation	Description	Mfr. *	Mfr. Part No.
R11	Resistor, fixed, composition, 820 ohms ±10%, 1/2w	O	LD
R12	Resistor, fixed, deposited carbon, 90,900 ohms ±1%, 1/4w	DP	DCF-1/4
R13	Resistor, fixed, deposited carbon, 10,000 ohms ±1%, 1/4w	DP	DCF-1/4
R14	Resistor, fixed, composition, 47,000 ohms ±10%, 1/2w	O	LD
R15 R29	Resistor, fixed, composition, 4700 ohms ±10%, 1/4w	O	LD
R16 R26	Resistor, fixed, composition, 8200 ohms ±10%, 1/4w	O	LD
R17	Resistor, fixed, composition, 15,000 ohms ±10%, 1/2w	O	LD
R18	Resistor, fixed, composition, 22,000 ohms ±10%, 1/2w	O	LD
R19	Resistor, fixed, composition, 68,000 ohms ±10%, 1/4w	O	LD
R20	Resistor, fixed, composition, 1500 ohms ±10%, 1/4w	O	LD
R21 R23 R34 thru R37	Resistor, fixed, composition, 1000 ohms ±10%, 1/4w	O	LD
R22	Resistor, fixed, composition, 180 ohms ±10%, 1/4w	O	LD
R23	See R21		
R24	Resistor, fixed, composition, 10,000 ohms ±10%, 2w	O	LD
R25	Resistor, fixed, wirewound, 16 ohms ±1%, 1w	DP	RS-1A
R26	See R16		
R27	Resistor, fixed, composition, 2700 ohms ±10%, 1/4w	O	LD
R28	Resistor, fixed, composition, 47 ohms ±10%, 1/4w	O	LD
R29	See R15		
R30	Resistor, variable, composition, 100 ohms ±10%, 2w	O	CLU-1011
R31	Resistor, variable, composition, 100 ohms ±10%, 1w	O	LD
R32	Resistor, fixed, composition, 27,000 ohms ±10%, 1/4w	O	LD
R33	Resistor, fixed, composition, 120,000 ohms ±10%, 1/4w	O	LD
R34 thru R37	See R21		
R38	Resistor, fixed, composition, factory-selected ±10%, 1/4w	O	LD
R39	Resistor, fixed, composition, 15,000 ohms ±10%, 1/4w	O	LD
S1	Switch, rotary, 4 pole, 6 position, shorting	CRL	PA-2010
S2 S3	Switch, toggle, DPDT	CH	7565K5
T1	Transformer, input	TT	JAF-1
T2	Transformer, output	UTC	A-15
V1 thru V6	Nuvistor, high mu	RCA	13CW4

*See "MANUFACTURERS' CODE LETTERS."

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